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Design of Dome Shaped Slot Antenna for Ultra Wide Band Application

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Abstract:
This is a presentation of microstrip-fed monopole with a compact dome-shaped wide-slot antenna for ultra wide-band application. The rectangular radiator and dome-shaped ground plane of an antenna are etched on FR4 substrate with permittivity 4.4 and loss tangent 0.02 with an overall size of 35× 36.5×1. 6mm3.Simulation and optimization carried out using CADFEKO suite 7.0. Dome-shaped slot provides a wide usable bandwidth up to 129% from 2.718GHz to 12.6GHz. The average efficiency is 75%, and stable VSWR (1.0-2.0) achieve over entire range in simulated results. The radiation pattern of E-plane and H-plane are directional and omnidirectional respectively with a stable gain.

Keywords: *UWB (Ultra Wide Band), VSWR (Voltage Standing Wave Ratio), MoM (Method of Moment), band notch, printed monopole*

1. Introduction

Regarding to the allocation and permits of the 3.1 GHz to 10.6 GHz unlicensed frequency band with 7.5 GHz wide bandwidth by the FCC, for the commercial use as a UWB. This UWB system holds the attention of all researchers day by day increases due to its advantages such as small size, light in weight, low cost, and high radiation efficiency. Small planar monopole antenna with different geometries is suitable to fulfill all advantages of UWB antenna [ii-iv].

In [v], by truncating the corners of the ground plane and strip-loaded technique were proposed to improve the radiation pattern and gain. An UWB antenna with three band notched characteristics was presented in [vi]. By inserting slots in microstrip feed line, a better gain pattern is achieve as compared to defected ground plane. Reference [vii] employed a hexagonal wide slot with microstrip fed gives the impedance bandwidth from 2.9 GHz to 18 GHz. In [viii], by cutting an inverted fork shaped slit in ground plane was improved the impedance bandwidth and for achieving dual band notched function, coupled inverted U rings strips in radiating patch are being used.

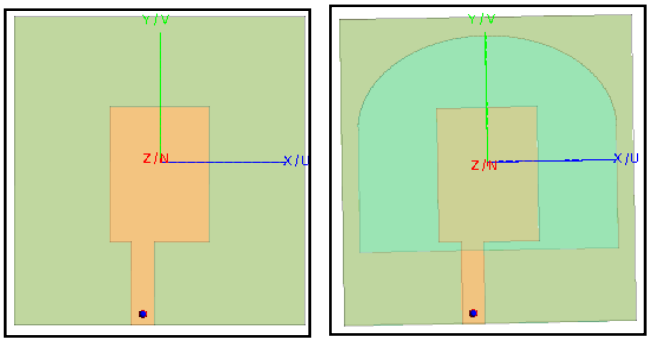
In this letter, a rectangular monopole UWB antenna with dome shaped slot in ground plane is proposed. The present paper proposed design of slotted UWB antenna which is different from other antenna in terms of its ultra wide range frequency from 2.718 GHz to 12.6 GHz. The design consists of a rectangular radiating patch with a wide dome shaped slot. The proposed antenna has dimensions of 35×36.5×1.6 mm^3.By choosing proper wide slot dimensions and position, the proposed antenna provides a high impedance bandwidth.

2. Antenna Design

The development proposed slotted UWB antenna shown in fig.1.Antenna consists of a substrate with a relative permittivity of 4.4, dielectric loss tangent of 0.02 and thickness of 1 mm which separates a rectangular radiating patch with 50Ω microstrip feed line of antenna.

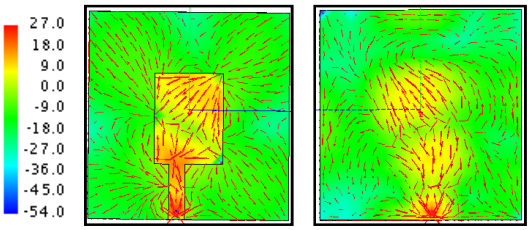
2.1. Development of Printed Monopole Antenna

Fig 1 shows the development of monopole antenna in which first figure Shows the radiating patch and back side with full ground then in next fig shows to improve the bandwidth wide dome shape slot cut from the ground plane for achieving the UWB range cut slot from the ground plane exactly back side of radiating patch due to maximum current concentration which is shown in fig 2. In fig.3 reflection coefficient graph of evolution of notched UWB monopole antenna.

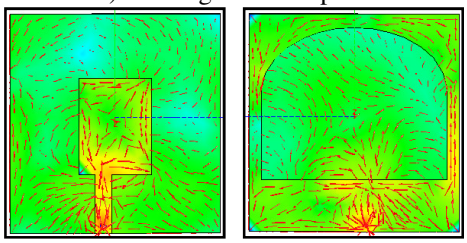


a) Rectangular monopole b) Slotted monopole

Figure 1: Development of printed monopole antenna



a) Rectangular monopole



b) Slotted UWB monopole

Figure 2: Current distribution at 6.8GHz

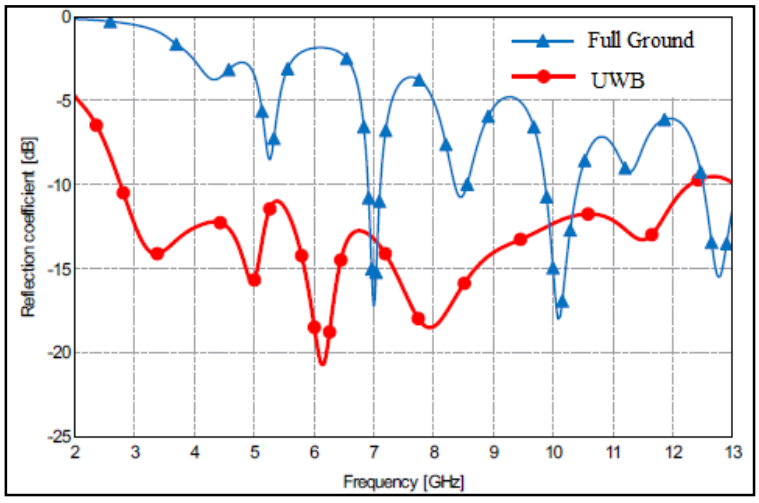


Figure 3: Development of monopole antenna VSWR

2.2. Parametric Study

There are number of geometrical and electrical parameters that affect the performance of the antenna. In this section two parameters were studied namely slot and feed line related parametric analysis of the antenna. By using simulation software CADFEKO 7.0, parametric studies were obtained with technique that, only one parameter is allowed to change at a time while other variables remained constant.

a. Slot related study*:* Fig.4 and Fig.5 shows effect of varying width and length of slot. The width of slot varying from 10mm to 32 mm. This width determines the wideband characteristics of antenna. It is seen that as width of slot increases, it has noticeable impact on the impedance matching at higher operating frequencies. Moreover Fig.5 shows antenna VSWR for different dimensions of length of slot. It is clearly seen from the figure that the length of the slot has a significant effect on the impedance matching. At higher operating frequency impedance matching affected by the high length of slot. The slot dimensions are important for matching the impedance of antenna.

b. Feed related study*:* Fig.6 demonstrate the effect of varying the position of feed line on impedance matching. By changing the feed position like as at center, left side and right side. We were getting desired results at feed shift to the left side.

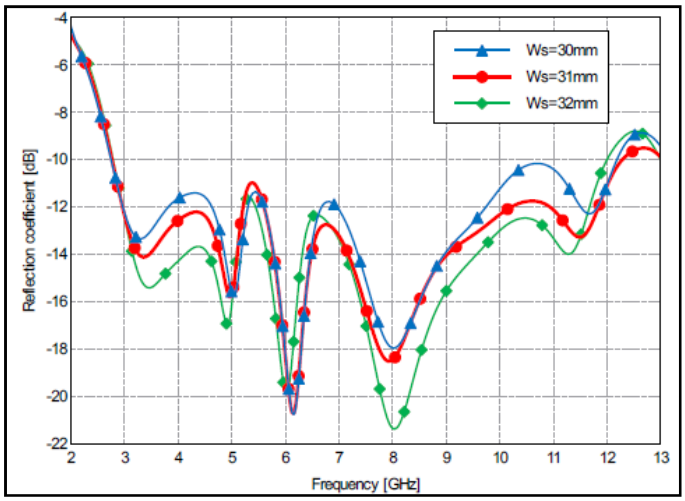


Figure 4: Effect of width of slot

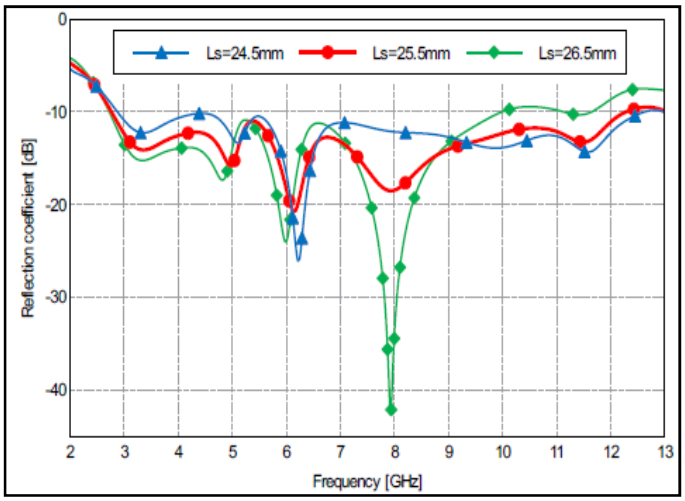


Figure 5: Effect of length of slot

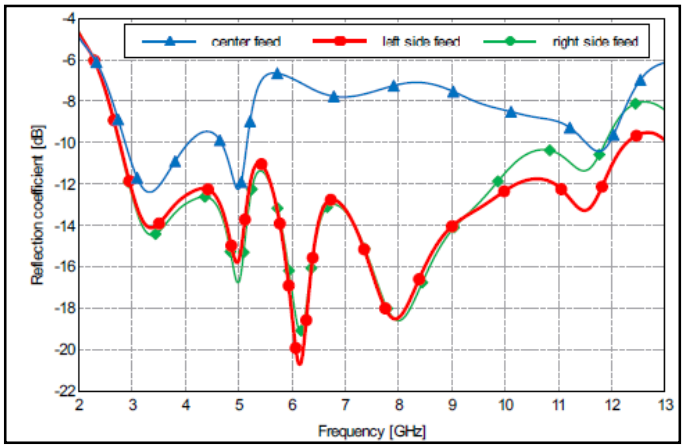


Figure 6: Effect of position of feed line

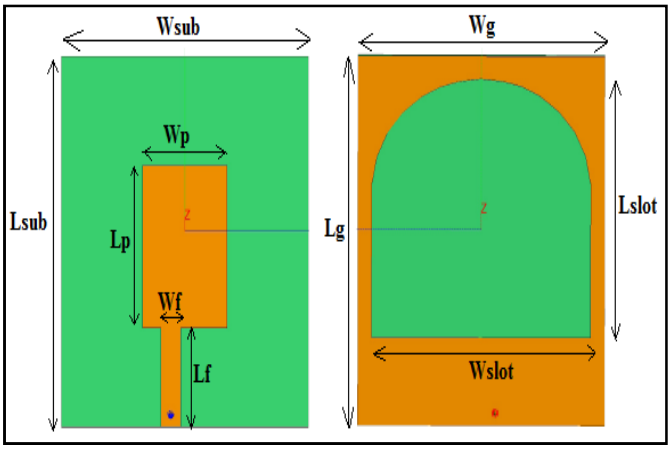


Figure 7: Geometry of rectangular monopole band notch antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
Wsub	35	Wslot	31
Lsub	36.5	Lslot	25.5
Wp	12	Wg	35
Lp	16	Lg	36.5
Wf	2.8	ε_r	4.4
Lf	8.8	tan δ	0.02
h	1.6	Substrate	FR4

Table 1: Design Parameters and Its Dimensions

3. Results and Discussion

The reflection coefficient and VSWR of the proposed antenna is shown in fig.8 and fig.9 respectively. The simulated bandwidth of the proposed antenna covers 2.718 GHz to 12.6 GHz for VSWR > 2:1 and return loss below -10 dB.Fig.10 shows the simulated and measured VSWR of Proposed antenna. Measured VSWR follows the simulated VSWR.

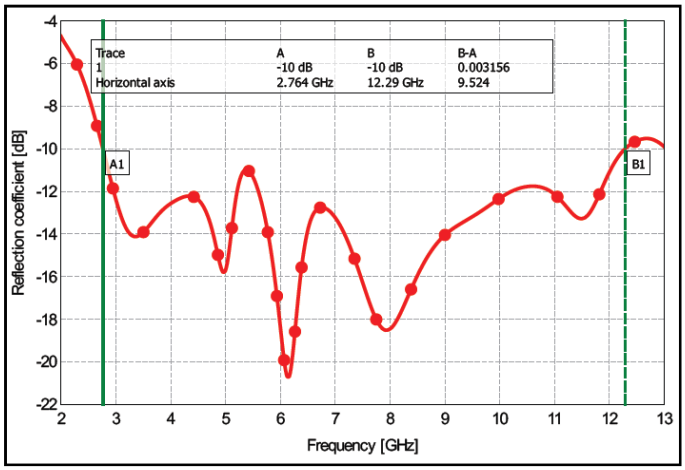


Figure 8: Reflection Coefficient of proposed antenna

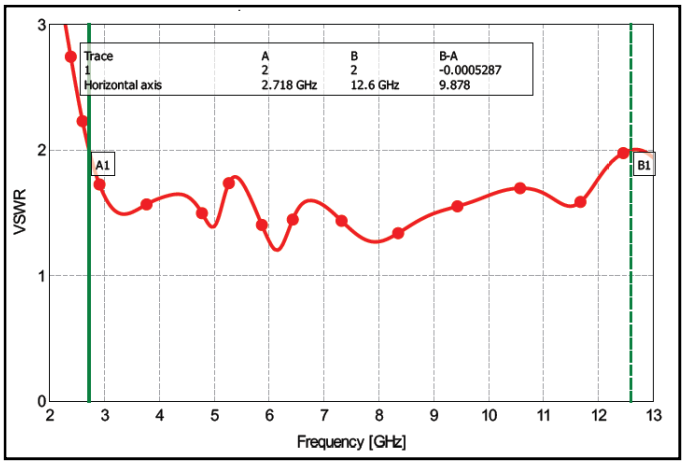


Figure 9: VSWR of proposed antenna

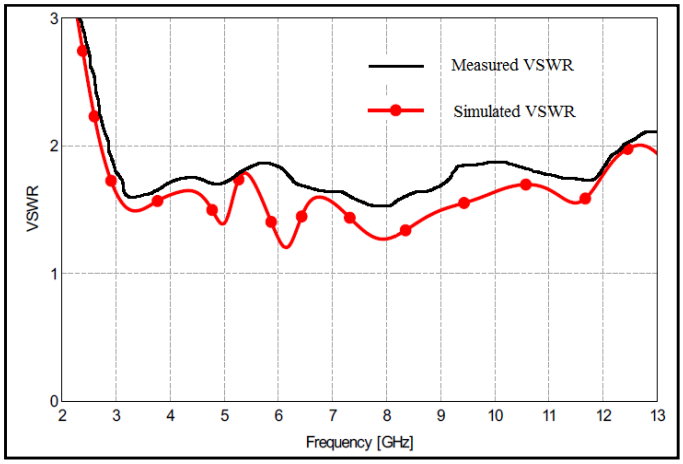


Figure 10: Simulated and Measured VSWR of proposed antenna

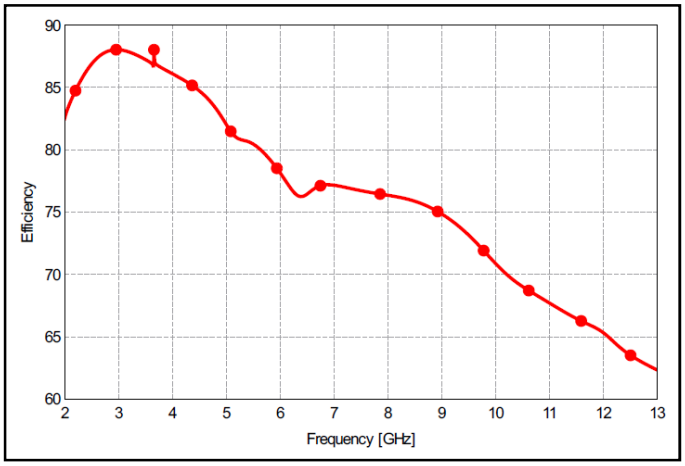
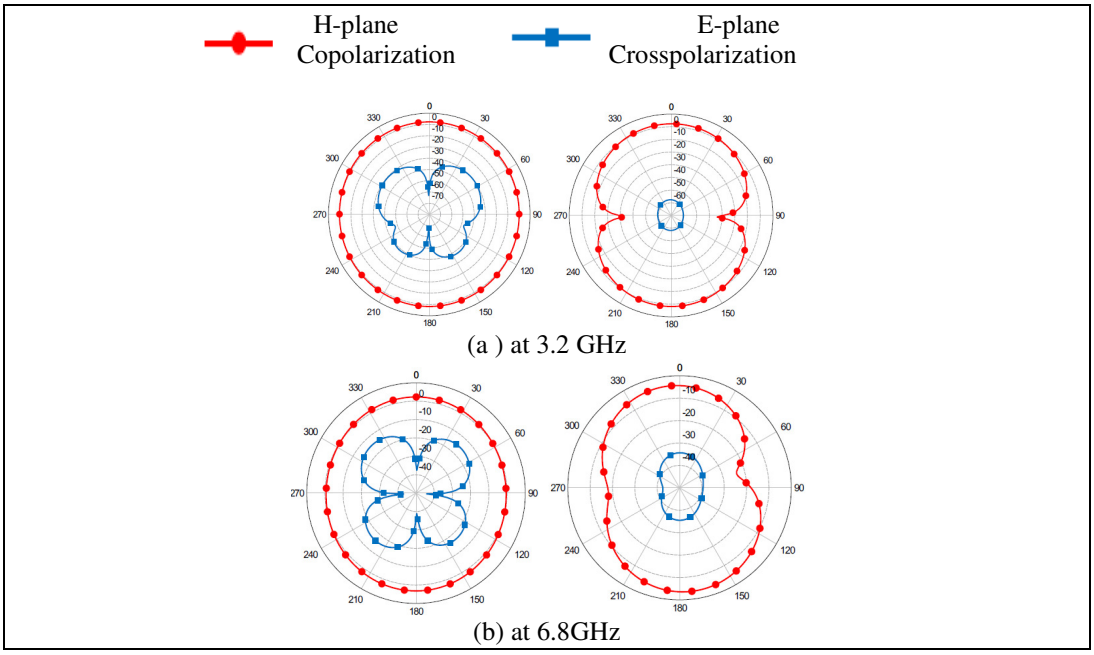
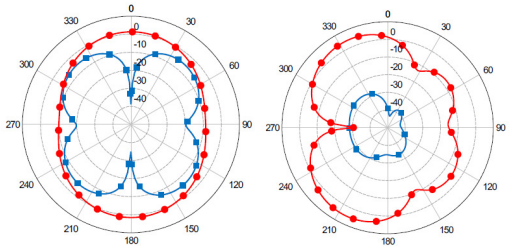


Figure 11: Efficiency vs. frequency of proposed antenna

Fig.11 shows the efficiency of proposed notched slotted UWB antenna.Efficiency decreases as frequency increases because dielectric loss of FR4 increases with increase in frequency.So for entire UWB the efficiency is greater than 75%which satisfies UWB requirements.Efficiency suddenly dropped at WLAN band.





(c) at 10.1GHz

Figure 12: H-field and E-field radiation patterns of optimized UWB slot antenna.

Fig.12 shows the simulated 2-D normalized radiation in both H-plane and E-plane for co-polarization and cross-polarization component at three different frequencies. It is seen that for all the frequency, E-plane radiations have almost bidirectional and dipole like radiation pattern and H-plane radiations have nearly omnidirectional pattern.

4. Conclusion

The proposed antenna is fully planar, simple and small in size. Dome-shaped slot enhanced impedance bandwidth by 129%. The antenna covers whole UWB from 3.1-10.6 GHz.The antenna shows stable radiation pattern and efficiency over entire UWB.

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